

Network Relations and Innovative Performance

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Abstract

Eight firms of the Portuguese moulds industry, all located in the region of Marinha Grande, were analysed as it regards their patterns of relationships with other actors within the sector or outside the sector, and its correlation with innovative performance. The information obtained through intensive observation allowed for the creation of an observation model of the moulds industry. This model is based on the type of existing interactions between firms (customers, suppliers, competitors) and between firms and other institutions (academic institutions, technological centres, research institutions).

The firms were not randomly chosen, and it was determinant for their inclusion in the sample their innovative reputation or performance. Although all the sample firms belong to the same industrial industry, different characteristics have emerged, allowing their grouping and classification along the lines of a value chain. Some of the firms are typically and almost exclusively producers, and their project and engineering capacity is very limited. R&D activities and product engineering and design activities are non-existent. A second category of firms have very well developed project and engineering capacities, as well as productive capacity, and are able to develop innovative solutions to demanding costumers. Information sources for innovation are essentially internal, coming out of R&D, and product engineering and design activities, developed internally. There is another category of firms that have no internal production capacity, which is contracted out to other firms.

The firms have different innovative behaviours, depending on the partner with whom informal relations are established. In general, the relations between firms and other firms, with firms and customers, with firms and suppliers, and even with firms and their competitors are extremely strong. However relations between firms and academic institutions, technological centres or research institutions are, as a rule, rarer and weaker, but the firms that have more relations with these kind of partners are also the more innovative ones and the more independent of customers.

The relations that are established by the firm vary according to the characteristics of the firm, namely its particular abilities which are associated with each nuclear area, their strategic position for the knowledge acquisition (i.e. from external sources) and knowledge creation (i.e. own R&D activities), and the position in the industry value chain. A model was constructed, based on the different relations profiles of the firms, on the position within the value chain that the firm occupies, and on the level of innovative capacity of the firm.

The model proves to be very useful in the analysis of the behaviour of the industry, by permitting a categorisation of each firm, and providing a clear picture of the industry as a whole. This research work is important because it permits the systematization and generalisation of the innovative dynamics in this industry.

1. Introduction

Analysis of the dynamics of technological change in traditional industrial sectors are often conducted without due consideration for the variety of firms that constitute the population of the sector (Fornahl and Brenner, 2003). Generally, the only variable that is considered for distinguishing firms is size, measured either by the number of employees or by sales volume. The use of this variable as a distinctive criterion became generalised because it permits to explore the now stylized assumption that large firms and small and medium enterprises are related by (sub) contractual relationships, where usually the SMEs are positioned in a rather dependent way relative to large firms. The patterns of relations or, in other words, the network of relations between firms in a specified sector are commonly explored using this frame of mind.

However, recent studies have explored in more detail the “inner workings” of industrial sectors (Alcaide-Marzal and Tortajada-Esparza, 2007; Smith, 2008), emphasizing variables such as linkages between actors, internal routines for knowledge acquisition or organizational patterns, among others. When analysing the Portuguese moulds sector we found that there is a considerable variation between species (firms) and that the patterns of relations, within the sector or with other firms or institutions outside the sector, differ in significant ways. Size is but one of the variables with explanatory potential (or it may even have no explanatory power at all) in explaining the variation.

The study resulted in the creation and proposal of an observation and analytical model of the moulds industry, relative to the type of relations that exist between the firms (customers, suppliers, competitors) and between firms and other institutions (academic institutions, technological centres, research institutions), which permits systematization and generalisation in the analysis of the innovative dynamics of this industry. It was observed that a significant variation exists between the firms that compose the industry, with large and differentiated impacts at the level of strategic approach, economic performance, innovative performance, and knowledge base of the firms.

2. A brief description of the Portuguese moulds industry

The national moulds industry is currently one of the most competitive industries in Portugal at international level. Although relatively recent (its origins go back no more than 60 years), it occupies a prominent place at world-wide level. It ranks in the eleven position in terms of the largest world-wide moulds producers and in the eighth position in terms of the largest world-wide injection moulds for plastic producers, exporting about 90% of its production (in 2008), with a total value of production of about 377 million euros.

This industry behaves as a strategic partner of its customers, supplying moulds engineering solutions, possessing the necessary experience and know-how for such. Factors related to project conception and production, to delivery times, to the rigorous quality control and the investment in high technology, have assured the continuity of the supply of Portuguese moulds to the more demanding international markets. As a matter of fact, this Portuguese industry has been growing and gaining projection, stimulated by external demand, and possessing a relation quality/price/delivery time competitive enough for these markets.

The success of the Portuguese moulds industry is due, basically, to the following aspects:

1. A very good international image;
2. A capacity to adapt itself to the technological evolutions and market;
3. A sensitivity to the innovation and modernization;
4. Productive capacity installed, with use of new technologies;
5. Human resources with strong empirical experience.

Presently, the moulds sector is constituted by approximately 535 firms, concentrated mainly in the regions of Marinha Grande (about 60% of the firms) and Oliveira de Azeméis (about 35% of the firms), employing about 8 350 workers, with the typical dimension of SME's, and with an added value greater than 80%.

Portugal is one of the largest world suppliers of precision plastic moulds. In 2008 it had as main markets Germany, Spain, France, Poland, the United Kingdom and USA. It was quite a different situation of the one in 1985 where the United States jointly with Canada were responsible for 65% of the total exported. Since the access of Portugal to the European Union, the European markets started to be the main clients of the national moulds sector and now represent more than 80% of total exports.

3. Literature review

Nowadays it is widely accepted that the growth of output and productivity depends on the development and the diffusion of new technologies (OCDE, 1997), that is, the technological progress leads to economic development. As such it is necessary that firms bet strong in innovation activities either to build some competitive advantage,

or just to remain in business.

The importance of the organizational factors in the development and application of new technologies (OCDE, 1997; Gopalakrishnan and Damanpour, 1997; Simões, 1997; Laranja et al., 1997) is consensual, once the organization is considered as a key element for innovation, being essentially a process to obtain, to manage and to use information, that later, will function as the basis of the decision. This process has one great intangible component. The innovation capacity will depend on the firm's learning capacity. As such, the use of the technology as competitiveness source depends essentially on the existing knowledge in terms of management, of the use of technologies and the interpretation of the markets.

Different studies (Edquist, 2005; Baranano, 2000; Meeus and Oerlemans, 2000; Freeman and Soete, 1997; Simões, 1997; Wolfe, 1994; Lundvall, 1992; Pavitt, 1984; Rothwell, 1977; Rothwell et al., 1974; Szakasits, 1974) have shown that external communication, i.e., the establishment of contacts with the external environment, is a crucial factor. The successful firms establish external contacts at several levels, mainly with other firms, who can be actual or potential customers, but also with suppliers and competitors. Contacts and relations also occur, less frequently, with public institutions with research or development activities and professional training activities, and also through external consultants. It was verified equally that the establishment of external contacts needs some internal requisites, such as a good coordination and internal cooperation, as well as an open and decentralized management.

The successful innovators, besides establishing good communications inside the firm, establish strong linkages and contacts with the scientific and technological community, as well as analyse with care potential and useful ideas created in the exterior of the firm. The contact with potential customers, since the beginning of the innovation process, is extremely important, since it allows understanding fully the customers' needs. "Technological innovation is a complex technical/social/economic process that involves strong linkages, either intra-firm, or between the firm and the economic, technological, competitive and social surrounding" (Rothwell, 1977; p. 203).

Information and knowledge are considered currently as the most important resources of a economy (Lundvall 1992) and, consequently, the most important underlying process is learning, being this a predominantly interactive process, framed in an institutional and cultural context. The learning is related with routine activities, in different areas of the firm, allowing the creation of important inputs for the innovation process. Lundvall (1992) considers that not all important inputs of the innovation process originate from R&D activities or from the existing scientific and technological knowledge. These routine activities, that are executed in a systematic way, that are specific of each firm, and involving diverse forms of learning ("learning-by-doing", "learning-by-using", "learning-by-learning", "learning-by-interacting"), also function as inputs extremely important for the innovation process.

Other authors (Tidd and Bessant, 2009; Edquist, 2005; Chung and Kim, 2003; Freel, 2003; Souitaris, 2001; Beeby and Booth, 2000; Sousa, 1997) refer the importance of the interactions between firms and the social and economic environment where they are inserted, and the connections that are established with consulting firms and science and technology infrastructure institutions, emphasising the importance of R&D centres, and education and training institutions. Optimization of these interactions results in the establishment of (business and innovation) networks that thrive on the complementarities of competences or assets, on mutual dependence and in new economic organizational forms not primordially governed by contractual bind but by relations based on trust and risk and benefit sharing (Teece et al., 1997).

Firms that show high levels of technological collaboration, either with other firms or with universities or research institutions, and acquisition of technology and mobility of human resources, seem to be able to improve their innovative capacity both in terms of product and process. Maybe because of that, geography and regions seem to have an accentuated importance for the development of systems and networks of new technologies. Local infrastructures, specialized human resources, local labour market, specialized services and personal relations are fundamental and contribute decisively to regional development (Muscio, 2006; Chung, 2002, Freeman and Soete, 1997).

The innovation process is not linear, but a complex and interactive one, involving business and non-business institutions. Kline and Rosenberg's (1986) "chain-linked" interactive model is an example of an innovation model that shows its interactive nature.

Accounting for its discontinuities and uncertainties, the concept of national and regional innovation systems help understand why technologies develop along certain trajectories. In the study of national innovation systems, the interactions between the several elements that constitute the innovation system, including firms, academia and research institutions, as well as other institutional actors, are analysed (Nelson, 1993; Lundvall, 1992; Freeman, 1987). The firms are at the core of this system, competing but also cooperating with each other (Dosi et al., 1988).

4. The empirical work

To test these linkages 8 firms of the Portuguese moulds industry (located in Marinha Grande), were studied through direct contacts. The information was collected using a semi-structured questionnaire. The questions addressed mainly the issue related to (internal or external) sources of information for innovation that the firms relied upon. It included, among many other topics, questions related to the importance of its relations with other partners or its participation in national or international projects. The questions were grouped in four categories:

- 1 - Internal sources:
 - R&D activities;
 - Product design;
 - Product engineering;
 - Accumulation of production experience;
 - Proposal of the workers;
 - Initiatives system;
 - Top management;
- 2 - External sources:
 - Competitors (analysis of competitors' products);
 - Customers;
 - Material and components suppliers (acquisition of material technology);
 - Equipment suppliers (acquisition of material technology);
 - Affiliated firms;
 - Acquisition of incorporated technology (licenses, know-how);
 - Joint ventures;
 - Consulting;
 - Technical services;
 - Promotion of national R&D programs;
- 3 - Education and research (institutions with R&D activities, national or foreigners):
 - University/Institutions (education);
 - Public and private research institutions;
 - Technological and formation Centres;
- 4 - Available information in a general way:
 - Fairs, expositions and samples of products;
 - Conferences, meeting, publications;
 - Patents;
 - Technical literature.

To obtain information about networks that were established between the studied firms and other firms (customers, suppliers, competitors), as well as with other institutions (academic institutions, technological centres, research institutions), there were questions related to the kind of institutions they appealed to when they needed external competencies. Questions were asked also about the level of formalization and the consistency and robustness of those networks.

5. An observation and analytical model for innovative firms of the Moulds Industry

In this section we present a detailed analysis of the differentiated characteristics of the firms, and show the implications in terms of innovative behaviour. Although all the sample firms belong to the same industrial sector, different characteristics have emerged, i.e., the firms present different competencies. It was possible to group and classify the firms in three categories. These categories reflect fundamental differences in the behaviour and characteristics of the firms. The three categories that were identified are described below.

The "Producer" category

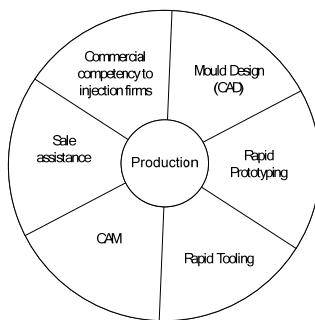
Firms that fall in this category have a high preponderance to develop process innovations, which is related to their high customer dependency, in terms of product conception. Product conception and development is, generally, made externally, by the customer.

In this type of firms, internal competencies necessary for the generation of ideas for product innovation are scarce. The main sources of ideas for innovation are the customers and, principally, suppliers of machines and equipment. It is the requirements and the demands of the customer, in terms of product specifications, that

compel the development of the production process. The relations with suppliers of raw materials are weak. Customers are the main drivers for the acquisition of new equipments that allow for the satisfaction of the requirements. Extended visits and training periods in customers firms, made under the initiative of the later, are frequent, and constitute some of the main mechanisms by which firms update their skills and knowledge base. The relationships with research institutions are tenuous or inexistent. Connections with universities do not exist, although firms are aware of their potential importance. There are some relations with sectoral technological centres, namely to obtain training in generic areas. Typically, these are subcontracted firms whose technological evolution depends on supplier and customer knowledge transfer and demand.

Using a graphical representation based on the capabilities approach of Teece (1998), the fundamental characteristics of the firms that fall under this category can be depicted in Figure 1. The central circle represents the core competencies possessed by the firm, and on which its competitive advantage is based. Other complementary competencies can exist internally or can be externally acquired.

Figure 1. “Producer” category competencies.



Source: Authors' elaboration, based on Teece's approach (1988).

The firms that follow under the category of “Producers” are typically moulds producers firms, having high know-how in moulds production, competencies in mould design (CAD), rapid tooling and CAM. These firms also present some competencies in sales assistance and commercial capacity directed towards injection firms, which are their main customers. However, these firms' capacities in terms of engineering and moulds conception are quite limited. R&D, engineering and product design activities are inexistent.

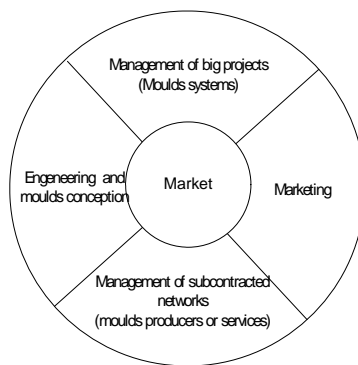
The “Commercial” category

The firm that falls in this category, which acts as a broker, has a mixed behaviour compared with the other two groups (“Producer” and “Industrial Design and Production”). The firm does not have internal production capacities. All production is contracted out to firms that are exclusively producers (the first category of firms) or to specialize service firms. This firm has engineering and project capacity, a deep and acute knowledge of the market and a high commercial performance. The characteristics of the firm are situated between the “extremes” represented by the other two groups. This firm has a strong internal project, design and engineering capacities, which makes it similar to the third group. In any case, commercial competencies, and the absence of internal production are the distinctive and strong features of this firm in this group.

This type of firm is fundamental for the survival of many firms of the moulds industry. This firm fulfils two functions that seem to be essential for many firms. The first is a commercial function of connection to external markets, that is absent from many firms (typically of the first group). Through the provision of this function, a substantial part of production of many firms is sold to external markets. A second function is related with the management of orders and product portfolio¹, and the realization of scale economies, through the coordination of the production activities of a set of enterprises. Commercial firms take advantage of the incapability of many firms to respond to, or manage, large orders and its corresponding integration and delivery times, and have built internal capacities of coordination that distribute production and capacity through a network of producer firms, creating the facto extended or virtual enterprises (Browne and Zhang, 1999). There are variations on the functions that are assured by the extended firm, as stated above.

¹ Market trends increasingly favour systems of moulds and not individual moulds.

Figure 2. “Commercial” category competencies.



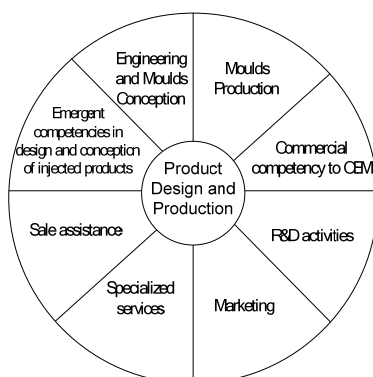
Source: Authors' elaboration, based on Teece's approach (1988).

The firm under the category “Commercial”, is a firm without production capacity, but subcontracts others firms that are typically producers (i.e., the firms under the first category “Producers”). It has a very well developed commercial capacity and is able to integrate others firms (producers and service firms). The main competency of this firm is the management of subcontracted networks (moulds producers or services), and the management of large production projects, i.e., moulds systems. This firm also presents competencies in engineering and moulds conception and marketing.

The “Industrial Design and Production” category

These firms have a quite developed component of engineering and project, as well as a developed production component. They are able to provide innovative solutions to the customers, autonomously. The level of dependency on their customers is very reduced, unlike the firms in the previous category, as they possess sufficient know-how and competencies to provide the solutions customers are seeking for. These firms have consistent relations with research institutions, although the perception is that those relations should be more frequent. There are interactions with several types of institutions, including universities, as well as research institutes and sectoral technological centres. These institutions function as partners in the makings of the solutions for technical problems that firms face in their product design and development activities as well as in their production activities. Internal design and engineering capacities, coupled with the previous mentioned sources of external knowledge, constitute the mechanisms for knowledge appropriation and utilisation. Product innovation is perceived as more important than process innovation, and firms pursue an active product diversification strategy.

Figure 3. “Industrial Design and Production” category competencies.



Source: Authors' elaboration, based on Teece's approach (1988).

The last group of firms is located at a higher level of the value chain of the moulds industry, comparatively to the two previous groups. Its competencies in engineering and moulds conception, jointly with the production capacity are very developed, and it also shows emergent competencies in design and conception of injected

products. This internal capacity for R&D and design allows the firms to offer its own endogenous solutions to customers, and the possibility or the consequence of entering into new and more demanding markets. The sources of information to innovation are fundamentally internal and they are the result of R&D activities. These firms also show competencies in sales assistance, marketing and specialized services. The last competency (specialized services) may suggest that these type of firms present a considerable level of vertical integration. With these competencies the firms are able to commercialize to OEM (Original Equipment Manufacturers), and that represents a significant ascension in the value chain of the moulds sector, coming close to the final costumer.

Table 1 summarizes and systematizes the characteristics of the three categories presented above. It is worthwhile to note that the behaviour of the first category of firms ("Producers") has strong similarities with one of the categories proposed by Pavitt (1984), namely the *supplier dominated* group, in terms of knowledge creation and appropriation, and the third category ("Industrial Design and Production") has significant similarities with the *specialized suppliers* group proposed by Pavitt. The supplier dominated group included the more traditional industries, where innovative activity relied mainly in the knowledge generated outside the industry. The specialized suppliers group included the equipment goods producers, whose know-how relied essentially in their own design and development. Pavitt's taxonomy tries to understand behavioural diversity in terms of acquisition and creation of technology, but it establishes differences between industries. In the case of this study, the industry is only one, but significant differences are visible at the level of individual enterprises. The association of characteristics and its generalization to an entire industry may hide a reality that is much more complex and diversified, suggesting patterns of evolution and change within the individual actors of the region.

Table 1. An observation and analytical model of the Portuguese Moulds Industry.

Type of firm (and names of the firms in each category)	Core competency	Source of Ideas	Main type of innovation	Customer dependency to innovation development		Relations with suppliers of:		Relations with competitors ²	Relations with academic institutions	Relations with research centres ³	Relations with training centres
					Raw materials ⁴	Machines and equipment	Software				
Producer - GECO - GRAMAQ - MATRISA - SOMEMA	Production	External	Process	Strong	Weak	Strong	Strong	Strong	Weak or inexistent	Weak or inexistent	Strong
Commercial (Broker) - TECMOLDE	Market	External	Process and Product	Strong	Strong	Strong	Strong	Inexistent	Inexistent	Inexistent	Inexistent
Industrial Design and Production - IBEROMOLDES - SOCEM - VANGEST	Product Design and production	Internal	Process and Product	Weak	Medium	Strong	Strong	Strong	Strong ⁵	Strong	Weak

Source: Authors' elaboration.

² Occurring only with some competitors, relative to which the classification is made

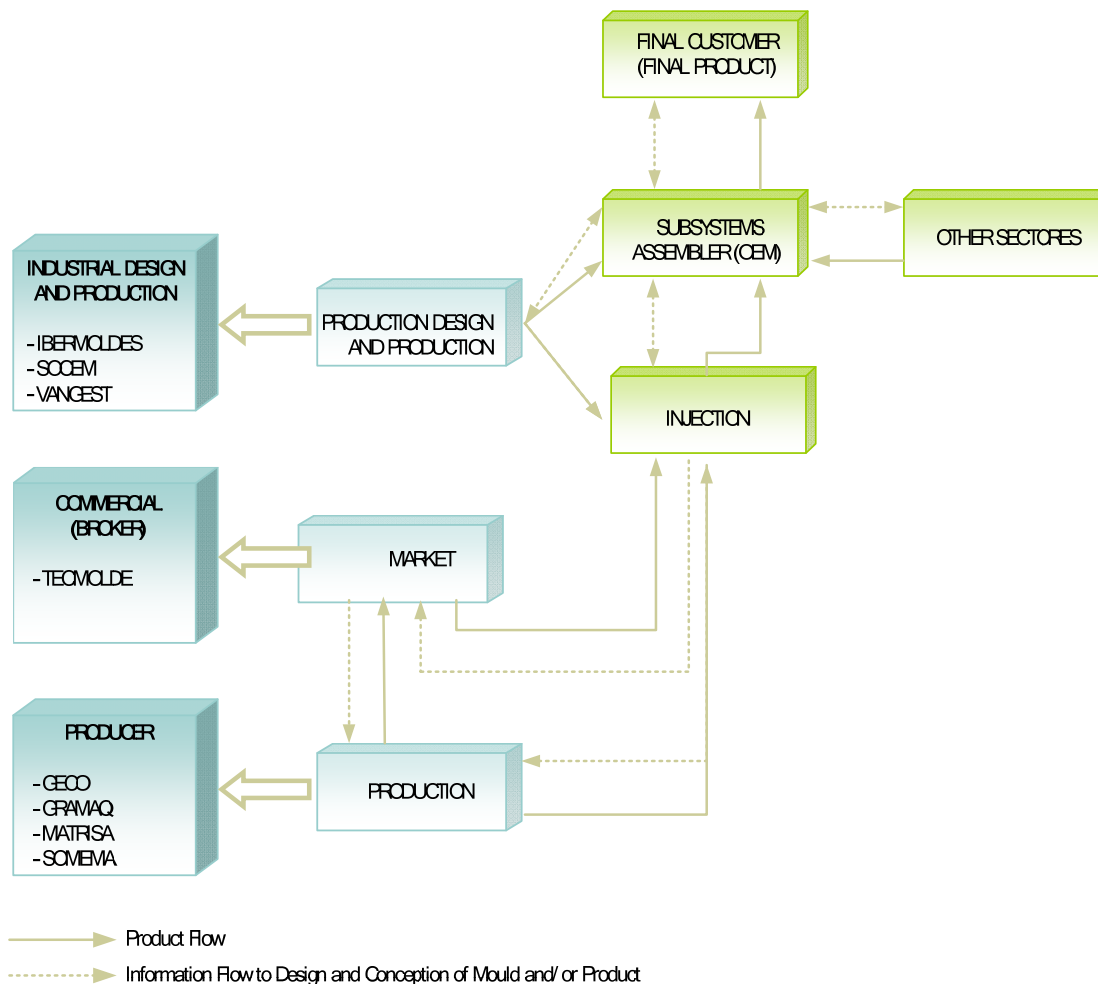
³ Referring to CENTIMFE (a sectoral technological centre) and INETI (a state laboratory)

⁴ Referring mainly to steel suppliers

⁵ It may be considered strong when compared with the other groups, although its intensity is still quite low

The differentiated profiles of each category imply a differentiated positioning of each one in the value chain of the sector. Those relations are represented in Figure 4.

Figure 4: Moulds sector's value chain and the relation with firms' typology.



Source: Authors' elaboration.

From the observation of the previous figure it stands out the different activities that constitute the value chain of the industry, including production and delivery of the final product to the final customer. It is also evident that the core competencies are intimately linked with the firms' typology and their position in the value chain. The three categories are represented in the boxes on the leftmost column. Inside the boxes, are included the names of the firms that were studied. The second column on the left represents the firms that specialize in the core competency depicted in the box. The two columns on the right represent the hierarchy of final customers of the firms under study. The diagram replicates very closely the final customers of the automotive sector, but it is also valid for the other customer industries. The arrows in full represent the flow of the product through the value chain of the industry. For instance, the "Producer" firms, specializing in "Production" are direct suppliers of the "Commercial" firms and the Injection firms (an intermediate client in the value chain, not part of the moulds industry), but are never suppliers of OEM. They receive knowledge, in the form of specifications, from these two types of firms, flows that are represented by broken lines/arrows. On the other hand, the "Industrial Design and Production" firms, specializing in "Product Design and Production" are direct suppliers of the injection firms but they also are direct suppliers of OEM. The direction of the knowledge flows is quite different in the case of this category of firms. They provide solutions both to injection firms and OEM, although they also are recipients of knowledge flows from the OEM.

6. Conclusions

It was shown the differentiated role of firms in an integrated industrial setting. The patterns of relationships of individual firms were analyzed in detail. These relations are complex and diversified, either in terms of partners or in terms of intensity, and there seems to be a relation between the innovative capacity of the firm and the pattern of interactions that it maintains. Intensive observation of eight firms of the sector allowed for the creation of an observation and analytical model of the moulds sector, in relation to the type of existing interactions between firms and other actors, and the individual patterns of knowledge creation and acquisition, revealing quite differentiated firm behavioral patterns and performance. Firm specific characteristics were related to the positioning of the firms within the value chain of the sector.

So we can conclude that the great competitive advantage of the Portuguese Moulds Industry depends on the capacity to establish strong networks with several kinds and types of partners, as we have seen, independently of the position in the industry value chain. However, the quality, frequency or intensity of these networks varies considerably. Networks between firms (customers, suppliers, competitors) are extremely strong. However networks between firms and other institutions (academic institutions, technological centres, research institutions) are, as a rule, rarer and weaker. The firms that have more networks with these kinds of partners are also the more innovative ones and the more independent of customers. The model that was constructed proves to be very useful in the analysis of the behaviour of the industry as a whole, and, as such, having the potential to be a very useful input in terms of policy or strategic decision-making.

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